CHAPTER 1

GENERAL

1. PURPOSE. This document provides criteria and guidance for the design of heating, ventilating and air conditioning (HVAC) control systems, and designates the standard control loops to be used.

2. SCOPE. These instructions describe frequently encountered control system loops, provide examples of how these loops are used, and provide guidance and criteria for the design of standard HVAC control systems and standard control panels. This document does not provide guidance on selecting HVAC systems and does not prohibit selection of system types not included herein.

3. REFERENCES. The following documents form a part of this technical instruction to the extent referenced:

a. Government Publications TM-5-785 Engineering Weather Data.
b. Government Publications TM-815-2 Energy Monitoring and Control Systems.

4. POLICY.

a. Adherence to the standards. The design of the HVAC control systems will not deviate from the standards established in these instructions, except where the design agency has an approved waiver request.

b. Control system designer responsibilities. The HVAC control system designer will be responsible for designing each control system required for the project HVAC systems, and will incorporate the control loops, control system sequences of operation, and HVAC control panel layouts (except when designing a Direct Digital Control (DDC) HVAC control system), using the symbols, abbreviations, and acronyms designated in these instructions. This design responsibility requires producing a design package that includes a specification, a set of drawings, and commissioning procedures for each HVAC control system. The designer will not depend on any HVAC control system vendor for the design of the HVAC control systems.

c. Control system vendor compliance. The HVAC control system vendor will be required by the contract documents to make the system product specific. The specification will require the HVAC control system vendor to produce shop drawings, schedules, instructions, test plans, test procedures, commissioning procedures, and other documents showing the application of products to implement the control system design. The specification will require that the HVAC control system vendor test the control system and document the test to show that the control system functions as designed, and to commission the control system.

5. CONTROL SYSTEM DESIGNER GUIDANCE.

a. Control system loops and control logic. These instructions include descriptions of loops for controlling temperature, humidification, airflow, and duct system static pressure. In addition, these instructions contain control logic for the following:

(1) Scheduling and initiating system operation.
(2) Changes in control modes of operation.
(3) Normal interlocks.

(4) Life Safety system interlocks.
(5) Special interlocks (such as for freeze protection).

b. Control system variations. These instructions show some of the possible HVAC system equipment and control system variations, and provide guidance and examples to show how the designer can modify control loops and systems for applications not specifically shown. The HVAC equipment and system variations for which control system guidance is provided include:

(1) Outside air preheat coils using hot water or glycol.
(2) Outside air preheat coils using steam.
(3) One-hundred percent outside air in lieu of outside air/ return air economizer.
(4) Deleting economizer control.
(5) Return fans.
(6) Exhaust fans.
(7) Humidity controls.
(8) Smoke dampers in HVAC supply air and return air ducts.
(9) Override of control of valves and dampers for freeze protection or smoke control systems.
(10) Startup and shutdown of HVAC fan systems by external systems such as smoke control.
(11) Variable speed fan drives.
(12) Combining systems in a common control panel.
(13) Unoccupied mode space temperature setback control of HVAC equipment.
(14) Building purge and recirculation modes.
(15) Variations in the use of control valves.

c. Project applicability. The HVAC control systems shown in these instructions are applicable to new construction building projects, building addition projects, building renovation projects, and (as further described in chapter 6) building retrofit projects.

d. Types of HVAC equipment covered. These instructions provide control system guidance for HVAC systems for heating, cooling, humidity control, ventilation and air delivery, terminal units, and small packaged unitary systems. Terminal units include Variable Air Volume (VAV) boxes, duct coils, fan coil units, unit heaters, gas-fired infrared heaters, and radiators.

e. Exceptions. These instructions do not cover control systems for HVAC equipment such as boilers and chillers, which usually have controls integral to the equipment.

6. DESIGN CONCEPT. The guidance contained in these instructions adheres to a particular concept for designing HVAC control systems. This concept includes the use of standard control systems that incorporate standard control loops. These instructions then show these control loops implemented in two different ways. One is with standard control system devices which are housed in a standard HVAC system control panel. This design concept also includes the use of single-loop digital controllers (SLDC) for the control of air handling systems and hydronic systems. The use of these controllers for such systems has been tested in the laboratory and in the field. The other method of implementation of the standard control loops in these instructions is Direct Digital Control (DDC) systems. Where DDC implementation differs from implementation with single-loop controllers, the DDC description will follow the descriptions of control via single-loop controllers. DDC control systems are widely available and have been in use for HVAC control for many years. However, these systems utilize proprietary hardware and software and, in general, are not compatible from one vendor’s system to another.

7. DDC VERSUS SLDC.

a. Background. "Single-loop" digital controls are currently the Army standard, but there are situations where direct digital control is a better choice. DDC is a more sophisticated technology and its use may be warranted in complex applications such as laboratory or medical facilities. A complex application may loosely be defined as one where numerous points must be remotely monitored and controlled. In this type of application the DDC system will likely include a dedicated operator work station (front-end or supervisory computer) which is staffed by an operator up to 24 hours per day. Waiver requests for the use of DDC systems may be approved by the District Commander or at the Division on a project by project basis, as with other Corps criteria. The design agent or district shall ensure that the customer understands the problems as well as the benefits of a DDC system and supports its use on the project. The district/division shall also ensure that proprietary DDC procurement is only included in a contract package when fully justified with strong, clear and accurate documentation.

b. Comparisons. Prior to making a decision on whether to use DDC as opposed to the SLDC technology, the designer is advised to consider the impact and ramifications of the decision. Comparisons include:

MULTI-LOOP DDC	SINGLE-LOOP DIGITAL CONTROLS
Commercial DDC systems are software-based with terminal connections, setpoints, calibration parameters, and calculations all handled by proprietary programs. Software operation, diagnostics and modification requirements vary by manufacturer.	The single-loop controller is industrial-grade and firmware-based, with relatively simple, straightforward configuration requirements and does not require programming capability. Army installations currently have personnel with the skills required to support the single-loop controller approach with minimal training.
With present DDC systems, software/hardware maintenance and repair or system expansion is vendor-dependent, resulting in sole source requirements that can potentially increase costs. This dependence on a single vendor for each DDC system is further complicated if the vendor drops support for older equipment or withdraws from the market. Historically, changes in the DDC market have been frequent .	The single-loop controller market is well established in the process controls industry. Single-loop controllers and other components of an SLDC-based system are interchangeable between manufacturers and are not dependent on any single vendor. SLDC systems' configurations are nonproprietary for maintenance, repair, and expansion. This nonproprietary arrangement can significantly reduce spare parts requirements.
Open competition and the low bid procurement environment could result in numerous proprietary DDC system manufacturers on an installation. Since each system would have different hardware, software, and maintenance requirements, in-house forces would have	SLDC-based systems should present fewer special training or maintenance problems as all replacement parts could be provided by a single manufacturer.

to maintain expertise in each manufacturer's equipment. Contract maintenance might be the only feasible way to maintain such systems, which could require the management and quality assurance of numerous contracts by the installation. The installation might also be subject to the high costs often associated with sole source maintenance contracts.

Since each DDC vendor has a different communication protocol and the development and acceptance of an industry standard communications protocol is not complete, the systems of different vendors cannot be easily interconnected and the application of any global control strategies would be difficult.

Interfacing an SLDC-based control system to a higher level computer could be achieved via a 4-20 mA signal which eliminates problems with proprietary manufacturer protocols.

DDC, used in a networked architecture, can provide a significant degree of functionality in that a multitude of operating parameters can be accessed, viewed, and modified from a remote location. This functionality is a built-in, well established, and time tested feature of most vendor's individual DDC systems.

SLDC-based control systems have been interfaced to a higher level computer in a networked architecture, but the functionality is more constrained than that of DDC and the methodology and technology for accomplishing this is less well established and more expensive than that of DDC.

Competitively procured commercial DDC systems may have a lower first cost in larger buildings where one panel serves several air handling units. However, if the panel fails, several HVAC systems may be out of service until the appropriate maintenance personnel can locate and diagnose the problem and make the necessary repairs. Reprogramming of the panel, if necessary, would require the services of an individual trained in that system's software.

In the event of a failure, only one unit or one control loop of an SLDC-based system would be affected until a nonproprietary controller or other component could be replaced. Since the single-loop controller is firmware-based and not software-based, no programming is required.

Software-based DDC systems can provide some energy saving features that local SLDC-based panels cannot provide. The actual incremental savings of these features is very site-specific.

Many local energy saving features as well as traditional cost effective global features, such as demand limiting, can be provided by SLDC-based panels in conjunction with the standard EMCS, a modified EMCS or a central FM system.

c. DDC system procurement

(1) Procurement. Procurement methods which have been used include:

(a) Write a five year requirements contract for DDC system components where the requirements contract is executed as a competitive procurement. Subsequent work done by controls contractors is then accomplished using government furnished DDC components. The contractor is responsible for providing all non-proprietary system components (valves, actuators, sensors, wiring, etc.), installing the government furnished proprietary components, and commissioning the entire control system. The disadvantage to this approach is that you may encounter compatibility problems after the 5 year contract expires as there is no guarantee that the same vendor will win the next contract.

(b) Write contract for SLDC, but indicate in the contract that in lieu of SLDC the contractor can provide DDC, but the DDC system must be compatible with the base-wide (UMCS or EMCS) system. This approach requires two designs and two specifications (one for the SLDC system and one for the DDC system). They will closely resemble each other, thus they are not both being developed from scratch. The separate designs must include all drawings and complete contract specifications. The selection of which system to use is up to the contractor. Using this approach, experience indicates that 70 to 80% of the time,or more, the contractor will provide the DDC system.

(c) Contract documents depict a non-proprietary DDC system, allowing for open competition. This approach is best used in single-building DDC applications where the control system is strictly "local" with no immediate or future need to interface with a supervisory system, and the facility has a dedicated maintenance staff, such as a hospital. This use of this approach is not recommended for multiple contracts or on a continuing basis because there is a high potential for eventually having a number of systems provided by different manufacturers. This leads to separate systems which have unique maintenance and training requirements, operating software, and generally will not communicate with each other without the addition of gateway interpreters.

(d) Sole source procurement of a single vendor's DDC system. The use of this approach is strongly discouraged due to the potential for protests which would delay contract award. A strong sole source acquisition justification and approval would be required on each project. If protested, it is questionable if the sole source acquisition justification could be substantiated since nonproprietary alternatives are available which surpass the minimum needs of the Army. The resolution of protests currently being argued may provide some insight for the use of this approach in the future; however, until that time, it is recommended that this approach be avoided.

8. CONTROL SYSTEM STANDARDS.

a. Standard instrumentation signals. The HVAC control system transmitter signals and the single-loop controller signals will be standard instrumentation signals of 4 to 20 milliamperes, which can be readily interfaced with any Corps standard EMCS, UMCS, or FM system and virtually any other central or head end system. When required, the controller output signal will be converted to 21 to 103 kPa (3 to 15 psig).

b. Actuators. Actuation of valves and dampers for HVAC systems such as air handling units and convertors will normally be by pneumatic actuators. These instructions also provide guidance on substituting electric or electronic actuators for pneumatic actuators.

c. Terminal unit control systems. Terminal unit control systems will use only electric or electronic control devices. The foregoing requirement for standard instrumentation signals does not apply to terminal unit control systems.

d. Standard controller. A single version of an electronic, self-tuning controller (generally known as a single-loop digital controller (SLDC)) will be used as the standard controller for HVAC systems in all applications except for terminal unit control-system applications (and when designing DDC systems). This type of controller has a history of reliable use, and is available from multiple sources as a standard product with the features described for its use in this manual. Using a standard controller will make control systems easier to maintain. The standard controller will accept one analog signal as a process variable input (PV) and one analog signal as a remote setpoint adjustment (CPA) input, and will produce one analog output signal (OUT). The controller will fit in a standard-size panel cutout. A controller of one manufacturer may be replaced by a controller of another manufacturer because several manufacturers produce the same version of the controller.

e. BACnet™ communication protocol.

(1) In some cases it may be desirable and beneficial to connect different vendors DDC field panels together to perform supervisory monitoring, management and control functions. The Building Automation and Control Networking (BACnet™) protocol provides a means to interconnect different manufacturers control equipment.

(2) BACnet™ is a communication protocol specification. The development of this specification was prompted by the desire of the building owners and operators for cost-effective inter-operability, i.e., the ability to integrate equipment from different vendors into a coherent automation and control system. Work on the BACnet™ specification began in June 1987 and was completed/approved by ASHRAE standards committee in June 1995 and approved by the American National Standards Institute in December 1995. Although the specification is complete, work is not yet complete on a specification for and a methodology for conformance testing of products claimed by vendors to be BACnet™ compatible.

(3) BACnet™ is intended as a standard communications protocol for HVAC&R. It is not directly intended for other building services such as lighting, fire and security although it does not preclude integrating these functions into a common system.

(4) BACnet™ is a mechanism that conveys information including, but not limited to:

(a) Hardware binary I/O values
(b) Hardware analog I/O values
(c) Software binary and analog I/O values
(d) Schedule Information
(e) Alarm and event information
(f) Files
(g) Control logic

(5) To use the BACnet™ standard the specifier should;

(a) Understand the structure of the protocol
- Conformance Classes
- Devices, Objects, Services
- Architecture

(b) Define your inter-operability needs at each level of the system: supervisory computer, operator interfaces, field panels, sensors/actuators.

(c) Choose which devices will be capable of sending and receiving messages.

(d) Define the functionality of the communicating devices (based on specifics/ definitions in the standard -- conformance class and functional groups).

(e) Define networking options. Be aware of the need for inter-networking devices (LANs, routers, repeaters, segments, gateways, and bridges).

(f) Obtain integration and commissioning services (from a vendor)

Rule 1: It isn't as simple as saying, "All devices shall conform to BACnet™ standard."

(6) The standard recommends use of a **Protocol Implementation Conformance Statement (PICS)** - although recent developments indicate that the PICS may be replaced by a related, but not yet official, requirement referred to as a BACnet™ Interoperability Building Block (BIBB). The PICS is a vendor developed document/submittal that defines the BACnet™ specifications supported by the product. The PICS includes:

(a) Basic Product Information

(b) **Conformance Class**. A product/device that meets one conformance class meets the requirements of all other classes with a lower number.

(c) Devices (or Functional Groups) supported (a collection of **Object** types and the **Services** they perform).

(d) **Object** types that are supported (18 possible).

(e) **Services** provided (standard and proprietary) (35 standard ones).

(f) Data Link Layer

Rule 2: Products claimed to be "BACnet™ compatible" require further clarification.

(7) The information provided above is intended as a primer to BACnet. Further information on BACnet and how to specify BACnet compliant systems is available from ASHRAE as well as the major control system vendors.

9. PROJECT IMPLEMENTATION.

a. Impact of other design disciplines on control system design. Design of HVAC control systems is largely driven by decisions on the overall building HVAC mechanical and electrical design. Therefore, design of the HVAC control system must be incorporated into the overall design process to insure adequate consideration of the space requirements for the HVAC control system's mechanical and electrical support services. Early involvement of the HVAC control system designer in the project can help prevent unfortunate HVAC system design choices that could result in marginally controllable HVAC systems. The control system designer's involvement should start with the development of the design concept and continue throughout the design process. The control parameter criteria (temperature, humidity, pressurization, occupancy schedules, etc.) must be defined for all systems. These criteria are the starting point for the HVAC control system design. The controller setpoints are shown on the HVAC control system contract drawings and are based on the HVAC system design criteria. The setpoints are guidance for maintenance of the control system.

b. Reuse of existing control devices. Renovation and addition projects require extra engineering work in the form of a detailed field survey of existing HVAC control systems to determine if existing control devices can be reused for the project, and, if so, the extent to which they require modification. Devices that use standard 4-20 milliampere or 21-103 kPa (3-15 psig) signals are among those which possibly may be reused. Existing control system components which do not meet the current specification requirements might be of questionable quality and/or reliability. The contract drawings must show control devices that will be reused, replaced, modified, or removed.

c. Locations of control devices. The designer will show the locations of wall-mounted instruments, HVAC control panels and outside air sensors, transmitters, and sunshields on HVAC floor plan drawings. The designer must show the location of sensing elements and primary measuring devices on the HVAC system drawings. The control system designer must coordinate with the mechanical designer to show the sensing location of the duct static pressure sensor on the HVAC ductwork drawing for a VAV system. This requirement is intended to insure that design consideration is given to these details so that the sensing will be proper and accurate, and to provide for clearance and access for maintenance of the control system. The locations of thermometers and pressure gauges should be selected for normal visual access by personnel required to read them.

d. Control device clearance and access. Control system elements must not intrude upon the space required for mechanical and electrical system maintenance access. The control system design must be coordinated with the HVAC system design to provide ductwork access to install and service sensing elements and transmitters including access doors for permanently mounted devices such as air flow measurement stations and in-line fan inlet guide vanes.

e. Location of permanent instrumentation. The location of the permanent instrumentation thermometers, spare wells, and valved outlets for gauges in piping systems must be coordinated with the HVAC system design and must be shown on the HVAC system contract drawings. Sufficient access space must be provided in the ductwork downstream of each air flow measurement sensor and array, to allow for a traverse with a portable instrument for calibration purposes.

f. Coordination with electrical system design. The designer will coordinate the control system design with the electrical system design to show power circuits for HVAC control panels, air compressor, and drier.

10. DESIGN PACKAGE REQUIREMENTS FOR HVAC CONTROL SYSTEMS.

a. Drawings.

(1) The designer will include standard HVAC control panel drawings to describe control panel construction and mounting arrangements as shown in chapter 4. These drawings are:

(a) Standard wall-mounted HVAC control panel arrangement.
(b) Standard HVAC control panel interior door.
(c) Standard HVAC control panel back panel layout.

(d) Controller wiring.
(e) Supply fan and return fan starter wiring.
(f) Exhaust fan and pump starter wiring.
(g) HVAC control panel power wiring.
(h) Damper schedule
(I) Control system schematic
(j) Ladder diagram
(k) Equipment schedule
(l) Terminal block layout

(2) Some simple control systems do not require a control panel and would not require panel drawings. DDC systems do not require a panel design, as these are available "off-the-shelf" from the system vendor.

(3) The schematic will show control loop devices and other permanent indicating instrumentation (such as pressure and draft gauges, thermometers, flow meters, and spare thermometer wells). The indicating instrumentation is intended to permit a visual check on the operation of the HVAC control system.

(4) Control systems for HVAC often require connections to boiler control systems, chiller control systems, variable speed drives, fire alarm and smoke detection systems, and EMCS. The schematic and the ladder diagram will show the interface points between field installed HVAC control systems, factory installed HVAC control systems, and other control systems.

(5) The ladder diagram will show the relationship of the devices within the HVAC control panel and their relationship to HVAC equipment magnetic starters and other control panels.

(6) The equipment schedule will show the information that the vendor needs to:

(a) Provide instrumentation of the calibrated ranges.
(b) Select control valves and associated actuators.
(c) Adjust the control system devices for sequencing operations.
(d) Configure the controller parameters, such as setpoints and schedules.
(e) Set the control system time clocks.

(7) The interior door layout will show the controllers, switches, pilot lights, pneumatic gauges, current-to-pneumatic signal devices, and other door mounted devices.

(8) The back panel layout will show the location of all other panel mounted devices, and will assign a back panel area for terminal blocks.

(9) The terminal block layout will show the location of specific terminal locations according to their function, and the locations of spare terminals and unassigned spaces.

(10) The drawings will be those shown in chapter 4 of these instructions for the standard HVAC control systems, with site-specific modifications and any additional control system loops required. The number of contract drawings necessary to show each control system varies with the system size and complexity. Most control systems in these instructions can be shown with the schematic, ladder diagram, and equipment schedule on one drawing, and control panel details on two drawings.

b. The HVAC control system specification.

(1) Because the HVAC control system designer has the responsibility to completely design the control system, the specification requires more technical detail than would be required if the designer needed to specify only the end performance result of control.

(2) The designer must specify extensive vendor submittal requirements. The submittals required are shop drawings, commissioning procedures, operating and maintenance instructions, training course documentation, a calibration/ commissioning/ adjusting report, testing documentation, and a list of service organizations.

(3) The control devices to be used must be specified in detail.

(4) Because the control system is electronic and can interface with various EMCS, the requirements for electrical surge protection devices installed in the system wiring must be specified, both to protect the HVAC control system and to prevent surges on HVAC control system wiring from adversely affecting the EMCS.

(5) Each control system must have a sequence of operation and a commissioning procedure.

c. Sequence of operation. Each control system will have a sequence of operation. The sequences will be included in the project specification or they may be shown on the contract drawings. Where the project HVAC systems are similar, the control loops and logic having identical control functions will be described identically in the sequences. The text of the sequences will vary only to the extent necessary to describe the operation of dissimilar control loops and logic.

d. Commissioning procedure. On projects that include HVAC system or building commissioning, the contract specifications and requirements for control system commissioning and other commissioning requirements shall be coordinated to support each other and ensure effective and accurate system and subsystem operation in accordance with the design with minimum duplication or conflict. The project specification for each control system will include a commissioning procedure. The commissioning procedure is a four-step process that details how the vendor will inspect, calibrate, adjust, and commission each HVAC control system. The types and quality of calibration instrumentation to be used in the procedure and the extent of documentation of the procedure will be specified. Where project HVAC systems are similar, the requirement for applying the procedure to control loops and logic will be described identically in each procedure. The text of the procedures will vary only to the extent necessary to describe the application of the commissioning procedure to dissimilar loops and logic. The four steps of the commissioning procedure are as shown in table 1-1.

TABLE 1-1 - COMMISSIONING PROCEDURE

Step	Activity	HVAC-System Condition	Purpose
1	System inspection	Shut down	Observe system for position of valves and dampers, and readiness of HVAC control panel.
2	Calibration accuracy check	Shut down	Collect one data point for each sensing element, transmitter, and controller combination under steady-state conditions.

3	Actuator range adjustments	Shut down	Set full-stroke travel of actuators matched to controller output range.
4	System commissionin g	Operating	Collect second data point for calibration accuracy check, tune controllers, observe control of HVAC system in each mode of operation, and observe the operation of safety devices.

11. EMCS INTERFACE WITH STANDARD LOCAL CONTROL PANELS. There are three feasible methods of interfacing the standard SLDC control panel with an EMCS or UMCS. A demonstration project at Fort Riley Kansas and associated research compared the analog/binary interface method to a digital communications and binary interface method. A third method uses frequency modulation (FM) switches. In deciding whether or not and how to interface the control panel with EMCS, the designer should consider the advantages and disadvantages associated with the available interface methods.

a. EMCS interface using analog and binary signals. The standard HVAC control panel designs include terminal blocks designated for interfacing with an EMCS using 4-20 milliampere (analog) input/output (I/O) signals and binary I/O signals. The analog I/O signals are used to interface the EMCS with the controller process variable retransmission and control point adjustment. The binary (contact closure) I/O signals are used to interface the EMCS with control panel shutdown and status devices and to override the control panel.

(1) Analog outputs to EMCS. Process variable retransmission (PVR) is a 4-20 milliampere analog output signal from each controller that is identical to the 4-20 milliampere PV input to the controller. The control system design will show HVAC control panel terminal blocks showing connections for interfacing controller process variable retransmission with EMCS.

(2) Analog inputs from EMCS. Control point adjustment (CPA) is a 4-20 milliampere analog input signal available to the controller that provides for adjustment of controller setpoints. The control system design will show HVAC control panel terminal blocks and wiring that allow connection of the CPA signal, from an EMCS device, to the controller 4-20 milliampere remote-setpoint input terminals.

(3) Binary outputs to EMCS. Freezestats and smoke detectors operate relays, located inside the control panel, as part of the HVAC control system shutdown circuits. Contacts of these relays are wired to terminal blocks in the HVAC system control panel for EMCS use. The economizer controller operates a relay located inside the control panel. A contact on this relay will be wired to terminal blocks in the HVAC system control panel for EMCS use. Differential pressure switches across the air handling system filters will have a contact in the device reserved for EMCS use.

(4) Binary inputs from EMCS. The control system ladder diagrams and HVAC control panel details will show provisions for override of HVAC control panels by:

(a) Replacing HVAC control panel time clocks with EMCS start-stop contacts.
(b) Installing EMCS override of the HVAC system's economizer controller signal.

(5) The advantages of this method of interface are:

(a) The EMCS can be used to perform basic monitoring and supervisory control functions.

(b) The 4-20 mA I/O between the control panel controllers and the EMCS remains non-proprietary and, in principle, any vendors EMCS can be interfaced with the controllers.

(6) The disadvantages of this method of interface are:

(a) In the absence of an industry standard communications protocol, the EMCS interface device (located in the field) and the EMCS central station are likely to be proprietary.

(b) In the absence of a control panel mounted time clock, the stand-alone capability of the panel is compromised. For example, with EMCS performing the time clock function, failure of the EMCS may result in loss of the time clock function.

(c) The electrical connection between the EMCS and the controller CPA port and/or PVR terminals may present ground loop problems thus requiring the use of loop drivers to provide for electrical isolation.

(d) The cost of the interface can be prohibitive. Preliminary results, based on one installed system, indicates a cost of about $12k per panel. Subsequent technological developments may lead to a lower cost.

b. EMCS interface using digital communication signals. Controllers are available with optional digital communications ports, such as Electronics Industries Association (EIA)-485. Using the communications port and vendor developed protocol, the control panel controllers can exchange data with an EMCS. Contact closure (binary) I/O signals are used to interface the EMCS with control panel shutdown and status devices and to override the control panel.

(1) Process variable retransmission (PVR) is not required. The functional equivalent is performed using digital communications. Delete the wiring between the control panel PVR terminal block connections and the controller PVR terminals.

(2) Control point adjustment (CPA) is not required. The functional equivalent is performed using digital communications. Delete the wiring between the control panel CPA terminal block connections and the controller CPA input terminals.

(3) Binary outputs to EMCS. Freezestats and smoke detectors operate relays, located inside the control panel, as part of the HVAC control system shutdown circuits. Contacts of these relays are wired to terminal blocks in the HVAC system control panel for EMCS use. The economizer controller operates a relay located inside the control panel. A contact on this relay will be wired to terminal blocks in the HVAC system control panel for EMCS use. Differential pressure switches across the air handling system filters will have a contact in the device reserved for EMCS use.

(4) Binary inputs from EMCS. The control system ladder diagrams and HVAC control panel details will show provisions for override of HVAC control panels by:

(a) Replacing HVAC control panel time clocks with EMCS start-stop contacts.

(b) Installing EMCS override of the HVAC system's economizer controller signal.

(5) The advantages of this method of interface are:

(a) With this interface, the EMCS can be used to perform monitoring and supervisory control functions.

(b) This method provides greater functionality than does the analog/binary interface method. All controller configuration parameters can be viewed and adjusted from the EMCS central station.

(c) This method of interface, in a demonstration project, was shown to be slightly less expensive than the analog/binary interface method primarily due to the need for less wiring.

(6) The disadvantages of this method of interface are:

(a) In the absence of an industry standard communications protocol, the EMCS interface device (located in the field) and the EMCS central station are likely to be proprietary.

(b) In the absence of an industry standard communications protocol, the control panel controllers are most likely to be proprietary. In addition, a later version of the same vendors controller may not be communications compatible, on a replacement basis, with the original panel controller(s).

(c) This method does not eliminate the need for a binary (contact closure) interface between the control panel and EMCS to accommodate control panel status devices (freezestats and smoke detectors) and override (time clock, economizer, remote safety shutdown, and remote safety override).

(d) In the absence of a control panel mounted time clock, the stand-alone capability of the panel is compromised. For example, with EMCS performing the time clock function, failure of the EMCS may result in loss of the time clock function.

(e) The cost of the interface can be prohibitive. Preliminary results, based on one installed system, indicates a cost of about $10k per panel. Subsequent technological developments may lead to a lower cost.

c. EMCS interface using frequency modulation (FM) switches. Locally mounted FM switches are controlled by one-way transmission from a centrally located FM transmitter. Individual switches may be used to override HVAC control panel operating modes. If this option is chosen, the designer should modify the control system ladder diagrams and HVAC control panel details to show provision for:

(1) Replacing HVAC control panel time clocks with FM switch start-stop contacts.

(2) Installing FM switch override of the HVAC system's economizer controller signal.

(3) The advantages of using this method of interface are:

(a) The cost is relatively inexpensive.

(4) The disadvantages of using this method of interface are:

(a) Funcionality is limited to binary outputs (contact closures).

12. FAN STARTER CONTROL CIRCUIT OVERRIDE BY EXTERNAL CONTROL SYSTEMS. The ladder diagrams for fan starter control circuits will show provisions for shutting down the fans and for overriding low temperature safety thermostats and smoke detectors to start the fans from external systems. These provisions are intended to allow interface with smoke control systems.

13. COORDINATION WITH HVAC SYSTEM BALANCING. The project specification will require that balancing is completed, that minimum damper positions are set, and that a balancing report is issued before control systems are tuned. Other control system commissioning activities may be performed independently of HVAC system balancing.

14. SYMBOLS. The standard symbols used in these instructions are shown in the glossary.

15. EXPLANATION OF TERMS. Terms, abbreviations and acronyms used in these instructions are found in the glossary.